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(56) Documents Cited
US 5051799 A US 4370523 A
RD 330050, Research Disclosure No. 330, 20 October
1991, page 769

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(54) Digital microphone

(57) A digital microphone comprises a housing 10, an acoustic-to-electrical signal transducer 20 disposed within the housing, the transducer being operable to generate an analogue audio signal; and a one-bit analogue-to-digital converter 30 disposed within the housing for converting the analogue audio signal into a one-bit digital audio signal for transmission to other, external, audio processing apparatus.

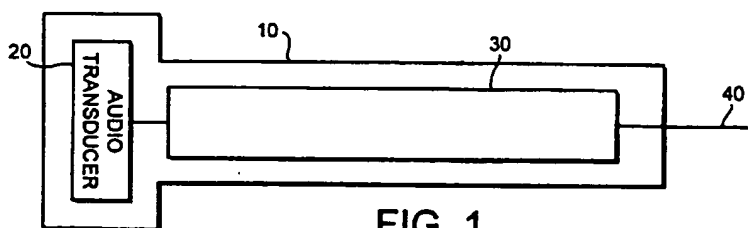


FIG. 1

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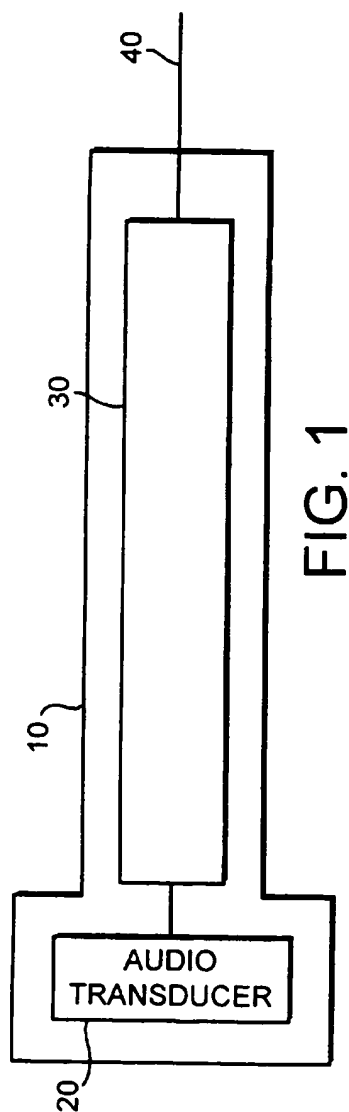


FIG. 1

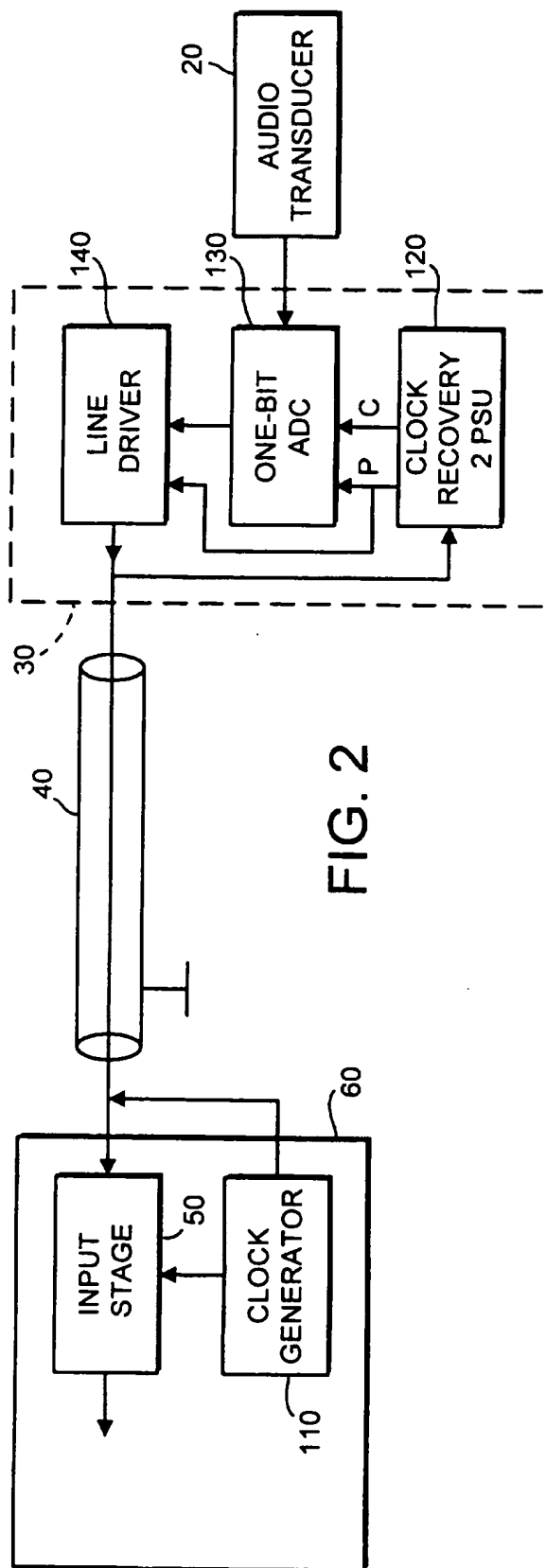


FIG. 2

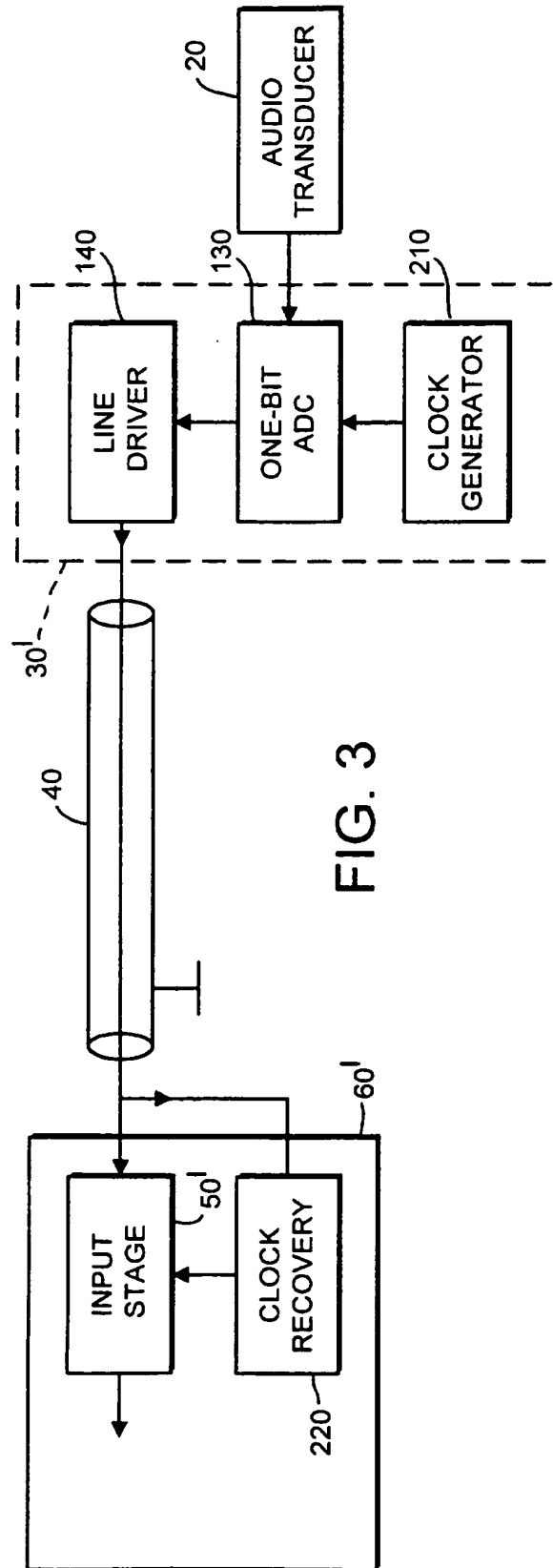


FIG. 3

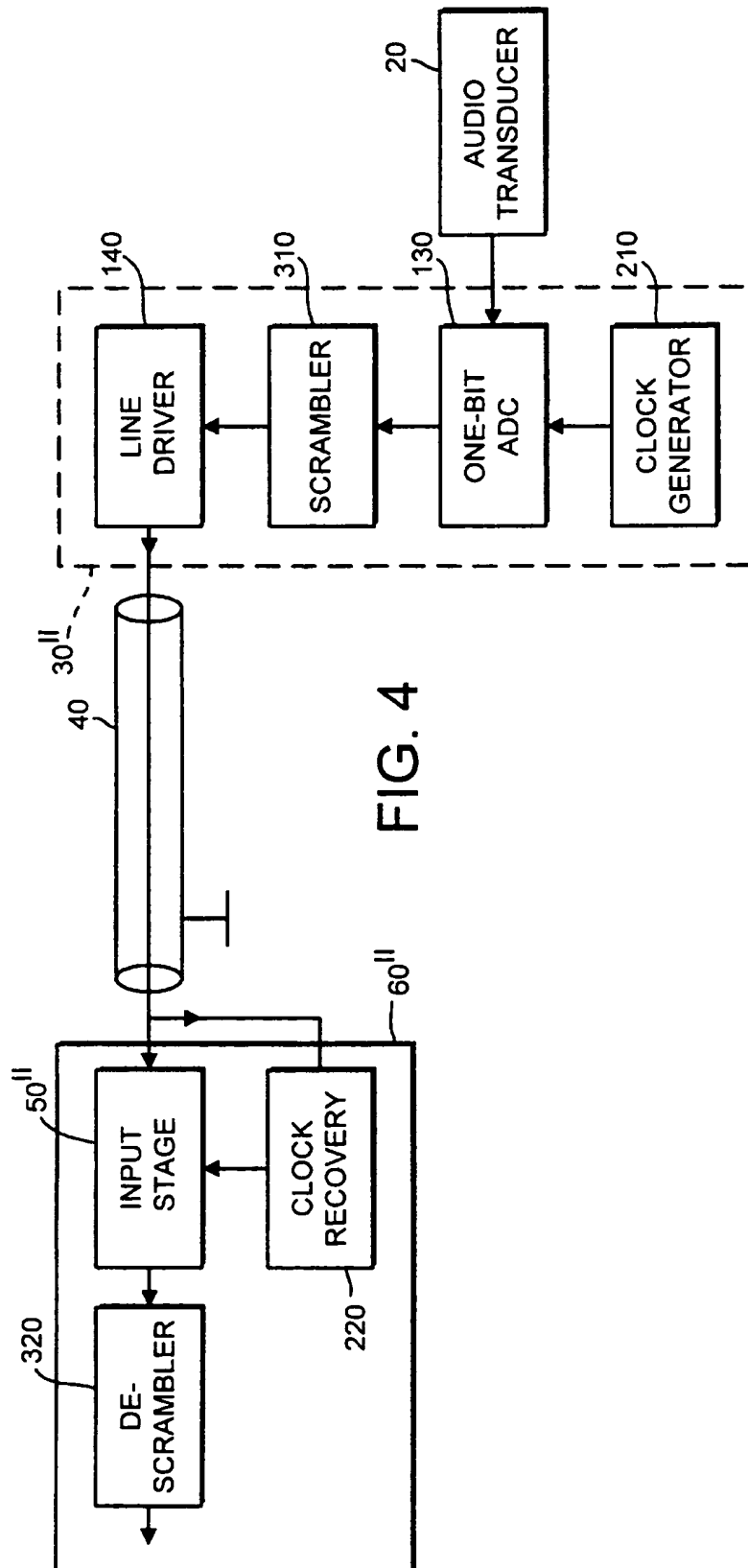


FIG. 4

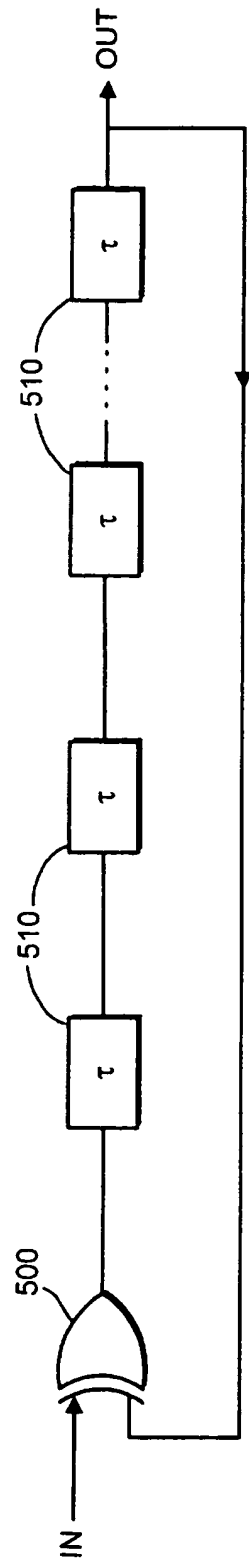


FIG. 5a

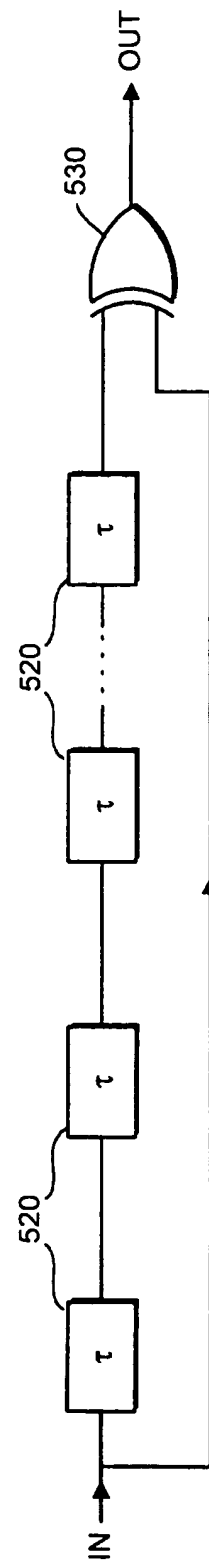


FIG. 5B

MICROPHONE

This invention relates to microphones, particularly for use in a one-bit digital audio system.

5 A microphone generally produces a low-level electrical signal in response to audible sound levels around the microphone. This low level electrical signal is then conducted along an electrical cable to subsequent processing apparatus - for example, a digital signal processing device such as an audio mixing console, where it is converted into a digital signal for further processing.

10 The low-level electrical signal is subject to induced noise and interference during transmission along the cable.

This invention provides a microphone comprising:

a housing;

15 an acoustic-to-electrical signal transducer disposed within the housing, the transducer being operable to generate an analogue audio signal; and

a one-bit analogue-to-digital converter disposed within the housing for converting the analogue audio signal into a one-bit digital audio signal for transmission to other, external, audio processing apparatus.

20 The invention can provide a microphone for use in a one-bit digital audio system having reduced noise and distortion because the low-level microphone output signals are supplied directly to the ADC without having to pass along long lengths of cable.

25 If the microphone is used in an audio system employing one-bit signals throughout, it avoids the need to carry out multi-bit PCM encoding at the system's input, with the attendant loss of bandwidth, added time delay and truncation errors in conversion. In particular, the time delay resulting from a PCM encoding stage is particularly troublesome for singers wearing headphones, where some part of the sound they hear is from the microphone / ADC combination; the time delay of a typical PCM ADC is about 1 millisecond. This delay corresponds to 30cm
30 propagation in air, which is similar enough to the mouth-ear distance to lead to comb filtering effects.

A further feature can also alleviate any problems due to feedback, given that

the audio band component of a one-bit digital audio signal is highly correlated with the input supplied to the ADC and the output of the line driver could easily be picked up by the sensitive input circuitry of the ADC.

5 To alleviate any such feedback problems, the one-bit signal for transmission on the coaxial cable is decorrelated from the audio signal by scrambling the digital data before supplying it to the cable driver. At the other end of the cable, a corresponding descrambler can be used.

10 As a further preferred feature, the scrambling process could be arranged so that if the microphone is powered down or unplugged, the descrambler (which now receives data representing a constant stream of zeroes) would generate a substantially equal distribution of ones and zeroes - a one-bit representation of digital silence.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

15 Figure 1 is a schematic diagram of a microphone;

Figures 2 to 4 are more detailed schematic diagrams of respective embodiments of a microphone connected to an input stage of a digital signal processing apparatus; and

20 Figures 5a and 5b illustrate a scrambler and complementary descrambler respectively.

Referring now to the drawings, Figure 1 is a schematic diagram of a microphone comprising a housing 10 in which an audio transducer (e.g. a microphone insert) 20 and a one-bit digital signal processor 30 are disposed. A transmission line such as a coaxial cable 40 carries signals from (and, in some embodiments, to) the signal processor 30.

Figures 2 to 4 are more detailed schematic diagrams of respective embodiments of the microphone connected to an input stage 50 of a digital signal processing apparatus 60.

30 In Figures 2 to 4, the following reference numerals are used to denote similar, though not identical, parts:

30, 30', 30'' digital signal processor within the microphone housing

50, 50', 50'' input stage
 60, 60', 60'' digital signal processing apparatus

5 The digital signal processing apparatus 60 could be, for example, an audio mixing console or effects unit operable to process one-bit digital audio signals.

 Starting therefore with Figure 2, the signal processing apparatus 60 includes a clock generator 110 which generates a clocking signal to which the one-bit digital audio signal from the microphone is to be synchronised. The clock generator supplies the clock signal to the input stage 50 and also, via the coaxial cable 40 (but in a "reverse" direction), to a clock recovery and power supply unit 120 within the signal processor 30 of the microphone.

 The clock recovery and power supply unit 120 generates two output signals: one is a straightforward clocking signal supplied to a one-bit analogue-to-digital converter (ADC) 130, and the other is a power output which supplies operating power to the one-bit ADC 130, a line driver 140 and (if necessary) the audio transducer 20.

 The power supply is derived from the clocking signal carried by the coaxial cable 40 by rectifying and smoothing the clocking signal. This avoids the need for a conventional "phantom power" arrangement, although conventional phantom power could be used instead if desired.

20 In operation, therefore, the audio transducer 20 generates an analogue-audio output signal dependant on sound levels in the vicinity of the audio transducer 20. The one-bit ADC 130 converts the analogue signal into a one-bit digital signal in accordance with the clock supplied from the clock recovery and power supply unit 120. The line driver 140 then amplifies the output of the one-bit ADC 130 to a suitable level for transmission via the coaxial cable 40.

 At the digital signal processing apparatus 60, the input stage (synchronised by the clock generator 110) terminates the coaxial cable 40 and "cleans up" the waveform of the digital signal transmitted via the coaxial cable 140 by using a threshold (e.g. a Schmidt trigger) to detect whether the signal on the coaxial cable 40 is above or below a threshold signal level, thereby generating a "clean" digital output for subsequent processing.

 A second embodiment is illustrated in Figure 3, where the digital signal

processing 30' includes a clock generator 210 which supplies a clocking signal to the one-bit ADC 130 as before. Also, as in Figure 2, the line driver 140 amplifies the output of the one-bit ADC 130 to a suitable level for transmission along the coaxial cable 40.

5 In Figure 3, the clock generator 210, the one-bit ADC 130, the line driver 140 and (if necessary) the audio transducer 20 are powered either by batteries or by conventional phantom powering.

At the recipient digital signal processing apparatus 60, the signal on the coaxial cable 40 is passed to a clock recovery unit 220 which recovers the clocking rate of the one-bit digital signal by synchronising a phase-locked-loop to the bit rate of the one-bit signal. The input stage 50' is synchronised by the output of the clock recovery unit 220.

A further synchronising stage may be required if the one-bit signal from the microphone is to be processed along with one-bit signals synchronised to other clocking sources (e.g. from other microphones).

Figure 4 illustrates a third embodiment which addresses three potential problems with the embodiment of Figure 3.

These problems are (i) it not always easy to recover a clocking signal from a one-bit digital audio signal; (ii) since a low-pass filtered version of a one-bit digital audio signal can be considered as a representation of the analogue audio signal, there is the danger that the relatively high signal levels output from the line driver 140 will be fed back (e.g. by induction) to the relatively low signal level input of the one-bit ADC 130, leading to possible feedback problems potentially causing non-linear distortion; and (iii) if the microphone is unplugged or powered down, the threshold in the input stage 50 could output a continuous sequence of the same bit value (e.g. zero) - which represents a very large signal level indeed in the one-bit digital domain.

These potential problems are addressed in the embodiment of Figure 4 by incorporating a status scrambler 310 in the microphone and a corresponding de-scrambler 320 at the recipient digital signal processing apparatus.

30 The scrambler 310 and de-scrambler 320 will be described in detail below with reference to Figure 5, but, briefly, their purpose is to ensure that the data transmitted along the coaxial cable 40 is relatively de-correlated from the audio signal

supplied to the one-bit ADC 130. This can reduce the problems of feedback between the output of the line driver 130 and the input to the one-bit ADC 130. Also, the digital content of the data signal can be changed so that it is easier for the clock recovery circuit 220 to recover a clocking signal from the scrambled signal.

5 Figure 5a schematically illustrates one embodiment of the scrambler 310, and Figure 5b schematically illustrates one embodiment of the complementary descrambler 320.

10 In Figure 5a, the signal to be scrambled is supplied as one input to a two-input exclusive-OR gate 500. The output of the exclusive-OR gate 500 is fed through a series of n one-bit delays 510 - where n could be, for example, between 8 and 16. The output of the final delay of the chain forms the scrambled data output and is also fed back to provide the second input to the exclusive-OR gate 500.

15 Similarly, in Figure 5b, the input data to be descrambled is supplied in parallel to the first of a chain of m one-bit delays (where m is the same as the value of n in Figure 5a) and to one input of a two-input exclusive-OR gate 530. The other input of the exclusive-OR gate 530 receives the output of the chain of delays 520. The output of the exclusive-OR gate 530 forms the descrambled data.

CLAIMS

1. A microphone comprising:
a housing;
5 an acoustic-to-electrical signal transducer disposed within the housing, the transducer being operable to generate an analogue audio signal; and
a one-bit analogue-to-digital converter disposed within the housing for converting the analogue audio signal into a one-bit digital audio signal for transmission to other, external, audio processing apparatus.
10
2. A microphone according to claim 1, comprising a clock generator for generating a clocking signal to synchronise operation of the analogue-to-digital converter.
- 15 3. A microphone according to claim 1, comprising means for receiving a clocking signal from external apparatus.
4. A microphone according to claim 3, comprising means for deriving a power supply signal from the received clocking signal, and for supplying the power supply
20 signal to the analogue-to-digital converter.
5. A microphone according to claim 4, in which the deriving means comprises a rectifier and a smoothing circuit.
- 25 6. A microphone according to any one of the preceding claims, comprising a data scrambler for scrambling the data generated by the analogue-to-digital converter so that the correlation between the scrambled data and the analogue audio signal is lower than the correlation between the output data of the analogue-to-digital converter and the analogue audio signal.
30
7. A microphone substantially as hereinbefore described with reference to the accompanying drawings.



The
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Application No: GB 9624668.1
Claims searched: 1 to 6

Examiner: Peter Easterfield
Date of search: 11 February 1997

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4J (JGC, JGF)

Int Cl (Ed.6): H04R 1/00, 3/00, 9/08, 11/04, 17/02, 19/01, 19/04, 21/02

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 5051799 A (PAUL et al) see col. 4 lines 41-45	1
X	US 4370523 A (BÄDER) see col. 3 lines 53-54	1
X	RD 330050, "Microphone with a 1-bit analog-to-digital converter", Research Disclosure, No. 330, 20 September 1991, page 769	1

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.

& Member of the same patent family

A Document indicating technological background and/or state of the art.
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